

## COLOUR CHANGING PRINTING IN AN INDUSTRIAL ENVIRONMENT; ON SELECTED POLYMER BASED FABRICS

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### ABSTRACT

With an increase of consumers dependent on the internet, fashion blogging and social networking, a new trend has seeped through into the market; personalized fashion. Incorporating an element of personalization into mass market fashion is essential to uplift the prominence in the global fashion market. To fulfill the above requirement, it is required to create a garment that is sensitive to the changes of its wearer, to its environment, and by changing its look according to the current condition, giving the wearer a sense of individuality. Colour changing prints are sensitive to certain environmental elements such as water, sunlight, and temperature. When in contact with one of the above elements, an alteration in its molecular structure results in a change of colour, giving the wearer a sense of personality as their clothes tune in and out of their engaged activities. Thus the principal objective of this study is to identify the feasibility of using colour changing printing technologies in an industrial environment on selected polymer based fabrics and to produce an outcome acceptable by industrial standards. The results highlighted that the technology of colour changing printing can be moved forward from conceptual fashion to being used within an acceptable industrial environment.

**KEYWORDS:** Personalized Fashion, Colour, Changing, Printing Technologies

### INTRODUCTION

Colour changing prints are sensitive to certain environmental elements such as water, sunlight, and temperature. When in contact with one of the above elements, an alteration in its molecular structure results in a change of colour, giving the wearer a sense of personality as their clothes tune in and out of their engaged activities.

Thermo chromic print, one of the colour chaning print, change colour in response to temperature fluctuations. With an increase in temperature, the print becomes colourless and with the lack of heat it changes back to its original colour. Photo chromic prints change colors when exposed to sunlight or artificial UV light at 365 nm called "black light." (Homola, 2008). Photo luminescent printing Commonly referred to as glow-in-the-dark, Photo luminescent prints are made by incorporating Photo luminescent powder into an ink base. Photo luminescent powder needs to be exposed to light (to be excited) in order to glow. Hydro chromic prints are moisture sensitive. It is a special binder which changes from white to transparent when in contact with water and changes back to the original white when dried. It can be screen printed onto cotton, polyester, nylon and their blended fabrics and nonwovens. Hydrophobic fabrics are unsuited to be printed on due to inferior adhesiveness. Hydro chromic ink has less elasticity and is unsuitable for printing on very stretchy fabrics. (Matsui International Inc., 2012)

The technology of colour changing printing has been around for some time and has been used on many industrial applications from medical thermometers to children's toys, right down to pizza packaging. (Homola, 2008) While 'high tech' and 'innovation' are tag lines of 21<sup>st</sup> century couture, many big players in the retail market are also following their lead in bringing innovation into mass production. For many retail brands, survival in the field comes through

innovative value addition. Colour changing inks are used as a value addition in terms of both technology and uniqueness in apparel products.

### **New Developments with Colour Changing Printing**

Amy Winters' inspirational collection incorporating both Hydro chromic and Photo chromic printing (Syuzi, 2010) opened up some interesting developments in colour changing technology within conceptual fashion, including her own next collection, 'structural colour'. An integration of art and science, the collection is printed in patented light sensitive ink, which responds to sunlight and ultraviolet rays. The UV blue textile ink appears to be invisible at daytime but glows electric blue under a black light at night. (Labarre, 2010) Alexandra Green of the London College of Fashion (Green, 2011) and Dahea Sun and Gayeon Lee from Central St. Martins (Eric, 2012) have gone the same way using Hydrochromic ink and newly developed pH sensitive fabric respectively. Catching on to retail fashion, Stella McCartney's best-selling running category featured Photo luminescent prints (Chua, 2010), while Viviane Jaeger and Emma-Jayne Parkes produce umbrellas with Hydrochromic prints for Squid London (Jaeger, 2012). The retail brand 'American apparel' has mass-produced their hypercolour t-shirts that change from colour to white when in contact with a source of heat. A collaboration between Winters and researchers at the Nano Photonics Centre, University of Cambridge, resulted in a new type of fabric, the 'polymer opal' lycra. The rubber-like properties of the fibers result in colour changes when bent stretched or twisted. Winters' collection; 'liquid bodysuit', 'liquid leggings' and a 'liquid armband', aptly demonstrate the amazing properties of the 'polymer opal' Lycra. (Eric, 2012)

### **Personalized Fashion and Color Changing Printing**

Fashion trends are currently taking on a whole new approach. While seasonal trends are losing their prominence, global fashion is largely dominated by two giants; technology and sustainability. With the Western consumer having less spending capacity and being more conscious of excessive retailing tendencies, seasonal fashion trends have slowed down to seamlessly blend into one another. However, a new trend is emerging. With an increase of consumers dependent on the internet, fashion blogging and social networking, another trend has seeped through into the market; personalized fashion.

Personalized fashion incorporates many elements. Street fashion is a predominant element in personalized fashion, where originality stems from either an ethnic background or a social group, rather than from a page off a trend report. It can also mean that the consumer is allowed to play the role of the designer, where technological improvements in digital and 3D printing allow wearers to completely customize their clothes. 'CONSTRVCT', for example, is an online fashion design studio where garments can be made to be custom fitted and printed with a photo of one's choice. (Huang, 2012) The company's founders Huang and Fizel aim to create fashion that's about participation and call their enterprise, "bespoke for the digital age". (Yoneda, 2012)

In response to the aforementioned trend moving towards personalization, an investigation is necessary with regard to incorporating an element of personalization into mass market fashion. To fulfill the above requirement, it is required to create a garment that is sensitive to the changes of its wearer, to its environment, and by changing its look according to the current condition, giving the wearer a sense of individuality. These are the grounds to further explore the technology of colour changing printing. Thus the principal objective of this study is to identify the feasibility of using colour changing printing technologies in an industrial environment on selected polymer based fabrics and to produce an outcome acceptable by industrial standards.

## METHODOLOGY

### Choose a Suitable Fabric for Experiments with Regard to End use

Prominent characteristics of polymer based fabrics commonly used in the active wear industry were identified through reviewing literature and the ratings were given in comparison to each other. A blend of Nylon Spandex (77% Ny 23% Sp) in a 290 GSM weight was chosen with regard to qualities such as superior stretch, moisture wicking ability and being minimally hydrophobic.

**Table 1: Prominent Characteristics of Polymer Based Fabrics - Adopted from (Kadolph, 2010), (Morton, 1993) and (The Fibre Source Website)**

	SPANDEX	NYLON	POLYESTER
Elasticity	Excellent stretch. Can be stretched more than 500% and still recover to very near its original length and shape. Has a higher retractive force than rubber.	Considerably good stretch in fabric, elastic and lace forms 100% Nylon has mechanical stretch.	Resistant to stretching and shrinking. 100% Polyester has mechanical stretch.
Wicking Ability	Excellent moisture wicking ability, which is why it's used so widely in active wear garments.	Good moisture wicking ability which can be improved by special finishes.	Good moisture wicking ability which can be improved by special finishes.
Moisture Absorption	Low	Low in moisture absorbency	Low
Dying Ability	Poor Normally not dye friendly except for a recently developed black colour by Lycra. Very expensive.	Average Nylon absorbs water, resulting in less dye bonding to the fibers.	Very good Dyed polyester expels the water in the dye but not the dye itself, which bonds with the fibers.
Thermal Retension	moderate	good	excellent
Resistance to Damage Damage	Resistant to deterioration by body oils, perspiration, lotions or detergents	Resistant to damage from oil and many chemicals	Resistant to most chemicals
Common uses	The largest segment is the sport and active market. Also used in swimwear, intimates and hosiery.	Initially created for women's stockings, now used for swimwear, sports & active wear, intimates and foundation garments, and ski and snow apparel.	Almost every category in apparel, including men's, women's and kids', from casual to active wear.
Blends	Spandex is often blended, in yarn form, with other fabrics; cotton, nylon and polyester to give a garment an additional level of comfort, support and fit.		Wearing polyester became associated with being cheap which drove industry manufacturers who began to re-label polyester in new blended fabrics.

### Develop a Set of Different Colour Changing Technologies

The printing experiments are the focal point of this project. The focus is to develop a set of prints that change according to the condition of the wearer and his/her environment. The prints that were developed are sensitive to changes in light, temperature and moisture content.

### Testing the Developed Prints within Accepted Industrial Standards

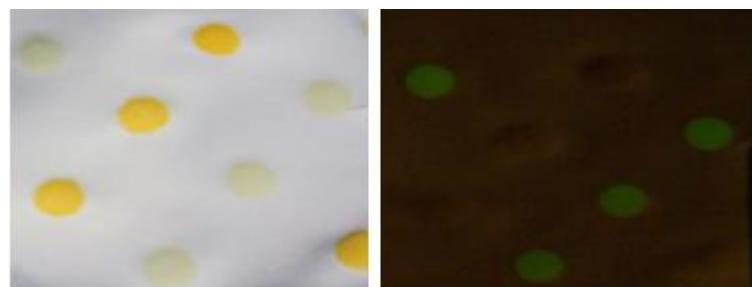
The testing was carried out to the standards of the M&S brand.

- M&S P15A; 2003 Extension and Modulus for weft knit fabric – to assess the extensibility of weft knit fabric
- M&S C7 – Colourfastness to Perspiration at 37 -/+2 °C in Acid and Alkali - to assess the degree of change of shade or cross staining due to perspiration.
- M&S C7 – Colourfastness to washing at 50 -/+2 °C - to assess the degree of change of shade or cross staining during washing.

## RESULTS AND DISCUSSIONS

### Develop a Set of Different Colour Changing Technologies

#### A Print Sensitive to Changes in Light Conditions



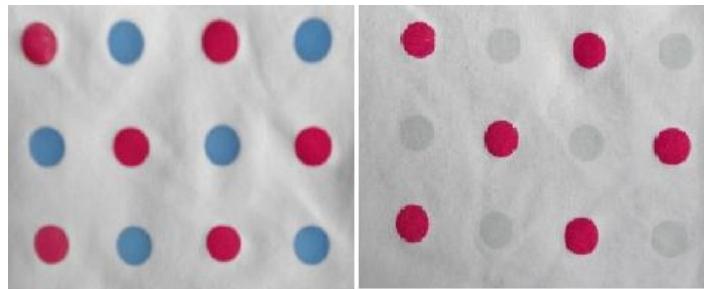
**Figure 1: The Photo Sensitive Print Exposed to Sunlight (Left), and Low Light (Right) [Photo by Authors]**

This print combines two techniques, Photochromic printing and Photoluminescent printing in alternating dots, so that it alters its state according to two distinct light conditions at day and night. The development is intended for running gear, as shown in the graphic below, which clearly illustrate a single garment with two differing reactions in the print caused by varying light conditions.



**Figure 2: The Photo Sensitive Print as Intended on a Garment, in Daylight (Left) and at Nighttime (Right) [Graphic by Author]**

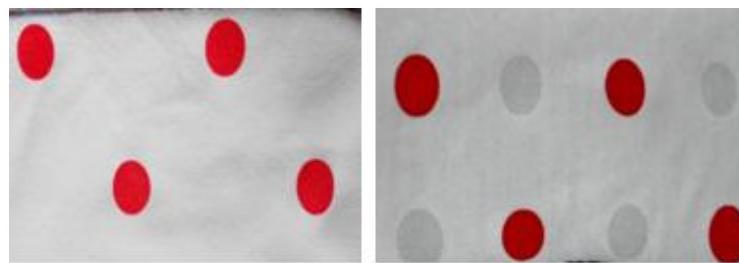
### A Print Sensitive to Changes in Body Temperature



**Figure 3: The Temperature Sensitive Print in a Low Temperature (Left) and a Higher Temperature (Right) [Photo by Authors]**

This print combines a Thermochromic print with a regular Plastisol print. Developed for gym, training or yoga, the print, shows off a bright cerulean colour in a low temperature and turns to a paler shade with the increase in body temperature induced by physical activity. The colour change is then reversed upon cooling down.

### A Print Sensitive to Changes in Moisture Content

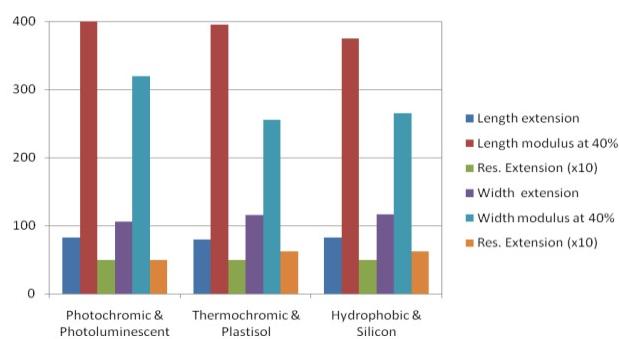


**Figure 4: The Water Repellent and Silicon Print when Dry (Left) and when Wet (Right) [Photo by Authors]**

This print combines silicon printing with a hydrophobic print. While the hydrophobic print remains invisible when dry, upon contact with water, the print becomes visible. The print was to be done using colourless silicon that is visible when dry and invisible when wet, contrasting with the water repellent which was invisible when dry and visible when wet. This development is best suited for swimwear or surf wear garments, specifically board shorts.

### Testing the Developed Prints within Accepted Industrial Standards

#### Extension and Modulus



**Figure 5: Extension and Modulus for Weft Knit Fabric (M&S P15A; 2003)**

Considering the high spandex content and the knitted structure in the fabric; it is obvious that photochromic print, which initially covered surface area, cracked when force was applied from both directions and left a rough hand feel and uneven texture.

## Colour Fastness Tests

Colour fastness tests are measured on a scale of one to five, written as 1.0, 2.0, 3.0, 4.0 and 5.0. Half marks are written as 1/2, 2/3, 3/4, 4/5 which is read as one-and-a-half, two-and-a-half, three-and-a-half and four-and-a-half. The expected standard for cellulosic and cellulosic blends are 4.0 or above and for synthetic and synthetic blends a 3/4 or above.

### Colour Fastness to Perspiration

**Table 2: C7 Colour Fastness to Perspiration at 37 -/+2 Celsius – Acid and Alkali**

Prints	Solution	Colour Change	Colour Staining					
			Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Photochromic & Photoluminescent	Acid	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Alkali	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Thermochromic & Plastisol	Acid	4/5	4/5	4.0	4.0	4.0	4/5	4.0
	Alkali	4/5	4/5	4.0	4.0	4/5	4/5	4/5
Hydrophobic & Silicon	Acid	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Alkali	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Neither the Photochromic and Photoluminescent print nor the Silicon and Hydrophobic print showed any change in colour or signs of colour bleeding in both the acid and alkali tests. Experiment combining colour changing pigment be mixed into a silicon printing base will have both extra elasticity and colour changing properties. The third print displayed a slight post-testing colour change. The thermo-chromic print showed no change in colour and reacted to temperature differences just as before. But the Plastisol stained the fabric and a slight fading of colour was also visible on the physical sample, but was within the parameters of the requirement. In the acidic condition, the colour bleeding was visible on the cotton and nylon strips and in the alkali condition, colour bleeding was seen on cotton and nylon, as well as polyester and wool. Even with slightly differing results, all the prints passed the industry requirement for colour fastness to perspiration.

### Colour Fastness to Washing

**Table 3: C4A Colour Fastness to Washing @ 50°C**

Prints	Colour Change	Colour Staining					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Photochromic & Photoluminescent	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Thermochromic & Plastisol	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Hydrophobic & Silicon	4/5	4/5	4/5	4/5	4/5	4/5	4/5

None of the prints showed any signs of colour change or colour staining across all categories of fiber after being subjected to the washing test.

## CONCLUSIONS

It was evident that none of the colour changing prints that showed an under average performance when subjected to testing. It was the regular Plastisol that encountered the small colour bleeding issue. Substituting the Plastisol with a silicon print would also increase its stretch and recovery while having a far superior hand feel. However further experiments combining colour changing prints with silicon or colour changing pigment mixing into a silicon printing base will enhance both extra elasticity. And colour changing properties. Carrying forward this research by experimenting on a wider range of fabrics in terms of composition, weight and structure would be interesting. Studying different effects

produced to those printed on white or lighter shades or even tackling issues like rough hand when printed over a pre-printed white base will be an interesting challenge for a researcher. Moreover this research highlighted the possibility of applying the technology of colour changing printing can be moved forward from conceptual fashion to being used within an acceptable industrial environment.

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